UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE

(2)

AD-A205 096

REPORT DOCUMENTATION PAGE

1b. RESTRICTIVE MARKINGS	
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for Public Release: Distribution Unlimited
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S) AFOSR-TR- 89-0198
6a. NAME OF PERFORMING ORGANIZATION Graham F. Carey The University of Texas at Austin 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Air Force Office of Scientific Research
6c. ADDRESS (City, State, and ZIP Code) Aerospace Eng. & Eng. Mech. Dept. Austin, TX 78748	7b. ADDRESS (City, State, and ZIP Code) Fluid Mechanics Program Bolling Air Force Base, D.C. 20332-6448
8a. NAME OF FUNDING / SPONSORING ORGANIZATION AFOSR 8b. OFFICE SYMBOL (If applicable) NA	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER AFOSR-87-0153
8c. ADDRESS (City, State, and ZIP Code) Bolling AFB Washington D.C. 20332-6448	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 61102F PROJECT NO. 2307 TASK NO. A1 WORK UNIT ACCESSION NO

11. TITLE (Include Security Classification)
Computational Fluid Dynamics (CFD): Element-by-Element Analysis for Advanced Computers

12. PERSONAL AUTHOR(S)
Graham F. Carey

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM 4/1/87 TO 9/30/88	88/11/14	05

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Parallel Processing, Domain Decomposition, Element-by-Element Method
	20.04		

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The research has focussed on a class of domain decomposition techniques for solution of problems in Computational Fluid Dynamics using advanced vector and parallel processors. In particular we consider finite element schemes and use the natural element-partition of the domain to construct the decomposition algorithm. This then fits conveniently into the usual framework of finite element calculations in which the primary loop is the independent calculation and assembly of element matrix and vector contributions. By recasting the conjugate gradient method at this level, the system matrix need not be assembled and the intensive matrix-vector product step can be completely parallelized. These ideas constitute a major departure from traditional finite element schemes and we feel our efforts are a major new development that will strongly influence the technology.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Dr. LEONIDAS SAKELL	22b. TELEPHONE (Include Area Code) (202) 767-4936 22c. OFFICE SYMBOL NA

DTIC ELECTE FEB 23 1989 S E

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

AFOSR Report
Grant #AFOSR-87-0153

Computational Fluid Dynamics (CFD): Element-by-Element Analysis for Advanced Computers

Principal Investigator: G. F.Carey, Director
CFD Laboratory, University of Texas

Overview: The research has focussed on a class of domain decomposition techniques for solution of problems in Computational Fluid Dynamics using advanced vector and parallel processors. In particular we consider finite element schemes and use the natural element-partition of the domain to construct the decomposition algorithm. This then fits conveniently into the usual framework of finite element calculations in which the primary loop is the independent calculation and assembly of element matrix and vector contributions. By recasting the conjugate gradient method at this level, the system matrix need not be assembled and the intensive matrix-vector product step can be completely parallelized. These ideas constitute a major departure from traditional finite element schemes and we feel our efforts are a major new development that will strongly influence the technology. One difficulty for CFD applications is, however, the convective term that leads to highly non-symmetric systems. The conjugate gradient scheme will not converge for such systems. To circumvent this problem we have been investigating and implementing biconjugate gradient and conjugate gradient squared techniques. Preliminary results indicate that we have resolved this difficulty.

Status: We have analyzed and implemented the EBE scheme on the CRAY XMP at Texas, and developed a vectorized scheme with vectorization over the number of elements. Hence vector lengths are very long. This scheme is also being implemented on the ETA-10 at Florida but we are still "ironing out" software problems. The algorithm for parallel processing CFD is different and has been examined, thus far, for parallel scalar shared-memory machines. Our calculations of test problems have been made at Argonne on the Sequent Balance (20 processors in parallel) and the Alliant FX-8 (8 processors in parallel). In late July we acquired an Alliant FX-8 at TICOM and the CFD lab is connected via ethernet to the Alliant (1 floor apart on the Dept. ethernet loop). We are now using this local Alliant and this will expedite our research and application studies.

Related Activities

ADVANCED PROCESSOR SYMPOSIUM: On Oct. 17, 18 I organized and hosted a symposium on "Methods and Algorithms for PDE's on Advanced Processors". A copy of the program and list of speakers is attached.

ITERATIVE METHODS CONFERENCE: A conference on Iterative Methods was organized with support from DOE, AFOSR, and with the sponsorship of SIAM, CNA and the CFD Lab. Over 150 attendees from the US and overseas participated in the 3-day conference which was organized to honor Dr. Young's 65th birthday and longstanding contributions to this field. All aspects of the conference were a great success. A copy of the conference program is attached. A conference volume of invited papers is to be prepared and contributed papers will appear in the journals Communications in Applied Numerical Methods and International Journal of Numerical Methods in Engineering.

AFOSR Reprints, Preprints and Presentations

Reprints and Preprints

Element-by-Element Vector and Parallel Computations, CANM, 4, No. 3, 299-307, 1988 (with E. Barragy, R. McLay and M. Sharma).

Supercomputing in Computational Fluid Dynamics, Computational Fluid Dynamics, G. de Vahl Davis and C. Fletcher (Eds.), Elsevier Science Publishers B.V. (North Holland), 21-30, 1988.

Least-Squares Finite Elements for First-Order Hyperbolic Systems, IJNME, 26, 81-93, 1988, (with B. N. Jiang).

A Parallel Element by Element Solution Scheme, IJNME (in press), March 1988, and CNA Report 214 (with E. Barragy).

Extension of Inverse Design Techniques for Multicomponent Airfoils, AIAA Journal, (in press), 1988, (with M. Siladic).

Presentations

Keynote Lecture, Supercomputing in Computational Fluid Dynamics, Computational Fluid Dynamics Meeting, University of Sydney, Australia, August 1987.

Distinguished Massman Lecture, Advances in Finite Element Methods and Supercomputing, The University of Notre Dame, Indiana, May 1988.

Seminar, Recent Advanced in Supercomputing and Computational Fluid Dynamics, Fluids Group, The University of Texas at Austin, April 1988.

In August, 1987, Dr. Carey delivered the keynote lecture opening the CTAC Computational Techniques and Applications conference in Sydney, Australia. The lecture will appear in the bound conference proceedings.

Dr. Carey gave an invited lecture at Griffiths University, Brisbane Australia, August 9 on "Supercomputers in Finite Element Computations".

In February 1988, Dr. Carey taught a short course on computational aspects of finite elements that included adaptive grid strategies, element-by-element techniques and advanced processors.

Students

M. Sharma, PhD Program
J. Batista, MS Program
J. Geld, MS Program
E. Barragy, MS Program

New Developments

Development and refinement of the element-by-element domain decomposition technique for Computational Fluid Dynamics on vector and parallel computers.

AFOSR Program Manager - Dr. James McMichael